Conjugate Product Graphs for Globally Optimal 2D-3D Shape Matching

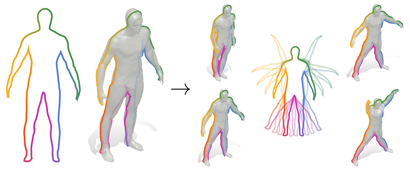
Paul Roetzer[1], Zorah Lähner[2], Florian Bernard[1]

University of Bonn[1], University of Siegen[2]

GIT PDF

2D-3D Shape Matching Applications

- 3D Shape Retrieval
- Augmented Reailty
- Medical Image Analysis
- 2D to 3D Deformation Transfer



Input Data

2D Outline
$\mathcal{M} = (\mathcal{V}_\mathcal{M}, \mathcal{E}_\mathcal{M})$
(Directed Graph)

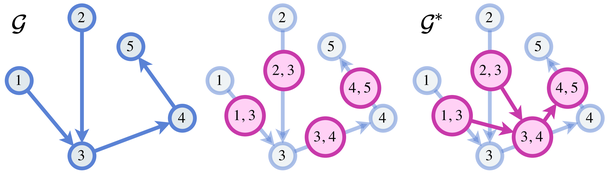
3D Triangle Mesh
$\mathcal{N} = (\mathcal{V}_\mathcal{N}, \mathcal{E}_\mathcal{N})$
(Undirected Graph)

Related Work

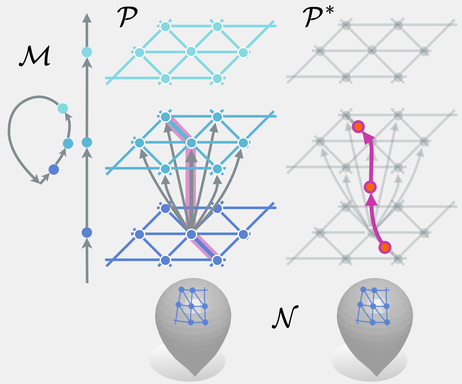
Lähner et al. [1] cast 2D-3D matching as finding shortest path in *product graph*:

- theoretical elegant formalism
- uses of high-deminsional features
- relies on **pre-matched segmentation** →

Conjuagte Graph Transformation



Conjugate Product Graph



- *Conjugate graph transformation* on product graph $\mathcal{P}$ yields **conjugate product graph** $\mathcal{P}^*$
- Increased expressiveness through **higher order** cost functions (i.e. *local rigidity*)
- Globally optimal matching via **shortest path**

Hierarchical Relationship:

$\mathcal{P}^* = (\mathcal{V}^*, \mathcal{E}^*)$ $\quad e^*$

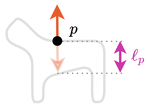
$\mathcal{P} = (\mathcal{V}, \mathcal{E})$ $\quad e_1 (= v_1^*)$ $\quad e_2 (= v_2^*)$

$\mathcal{M}, \mathcal{N}$ $\quad e_1^\mathcal{M}$ $\quad e_1^\mathcal{N}$ $\quad e_2^\mathcal{M}$ $\quad e_2^\mathcal{N}$

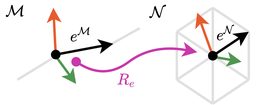
Higher Order Cost Function

Cost $d(e^*)$ defined on a conjugate product edge e^*:

$$d(e^*) = d_{\text{data}}(e^*) + d_{\text{reg}}(e^*)$$

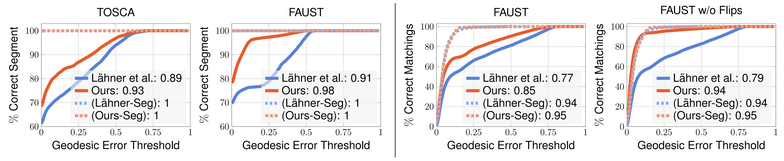


(Data) **Local Thickness**
L_1-difference between 2D and 3D

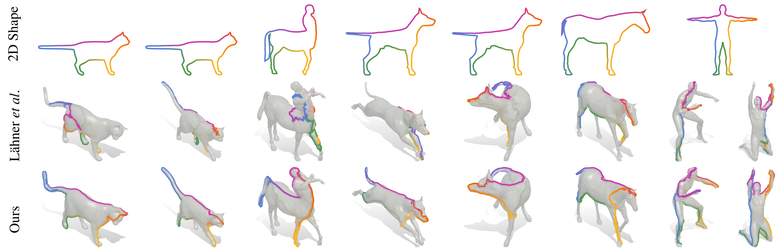


(Regulariser) **Local Rigidity**
SO(3)-distance of subsequent rotations

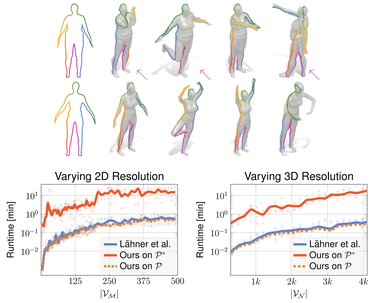
Results



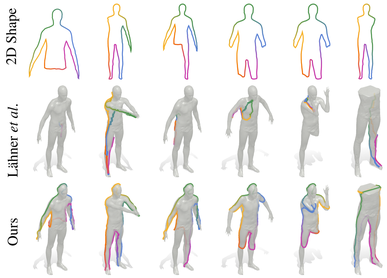
Tosca



Faust and Runtime



Partial



References

[1] Zorah Lähner, Emanuele Rodolà, Frank R Schmidt, Michael M Bronstein, and Daniel Cremers. Efficient globally optimal 2d-to-3d deformable shape matching. 2016.